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BEET SUGAR PRODUCTION.

INTRODUCTION, BY C. E. THORNE.

In 1891 the United States Department of Agriculture distributed sugar beet seed to farmers in many of the states, and determined the percentage of sugar in samples of beets grown from this seed. The results of this test, as compiled and published by Dr. H. W. Wiley, chemist, in Bulletin 33 of the Department, indicated that beets might be grown for sugar with profit throughout the northern half of Ohio, and in other regions of similar latitude.

In 1892 this Station offered to make free determinations of sugar in such samples of beets, grown within the state, as might be sent in for analysis. A number of such samples were received and examined, with results confirmatory of those arrived at by Dr. Wiley.

Since that year the Station's work has been interrupted by the removal from Columbus to Wooster, this removal involving the complete re-equipment of the Station with lands, buildings and laboratories, and the added work which was thus laid upon the Station staff made the abandonment of some lines of work previously undertaken a physical necessity.

The numerous inquiries which are now being received by the Station, relative to the outlook for profitable beet sugar production in Ohio, indicate a general revival of interest in this subject, and in order to place before the farmers of the state the latest and most reliable information attainable, we republish, on the following pages, a bulletin just issued by the Agricultural Experiment Station of the University of Wisconsin, and compiled by Director W. A. Henry, of that Station, omitting a few pages which are chiefly of local interest, and adding a few notes drawn from our own experience.

In the introduction to his bulletin Director Henry states that the data employed have been in part furnished by investigations conducted by his Station from 1890 to 1892, inclusive, under the immediate care of Prof. F. W. Woll, and in part compiled from the following sources:

Bulletin 27, Department of Agriculture, Washington; *The Sugar Beet*, (monthly), Philadelphia; *The Sugar Planter* (weekly), New Orleans; *The American Agriculturist* (weekly), New York City. Obligations are also acknowledged to the Norfolk, Nebraska, beet sugar factory for photographs and to the late Hon. J. M. Rusk, for helpful assistance during his term of office as Secretary of Agriculture. Director Henry writes as follows:

BEET SUGAR PRODUCTION.

BY W. A. HENRY.

Historical—The commercial production of sugar from the beet root is perhaps the highest example it is possible to present of the value of science to the development of agriculture. In 1747 Margraff, a member of the Berlin Academy of Sciences, reported that of a number of plants examined by him the beet root carried the most sugar, and he made the prophecy that Europe would find in the beet the basis of a new industry. He produced sugar from the beet root in a limited way by laboratory experiments. The matter lay dormant for half a century, when, in 1799, one of Margraff's pupils, Achard, exhibited to the Institute of France a sample of sugar from the beet root and affirmed that from this source brown sugar of good quality could be produced at a cost not exceeding six cents per pound. A commission to investigate the claims reported that sugar could be obtained from the beet root at a cost of 18 cents per pound, stating that this figure might possibly be lowered by improved methods. The French people did not awake immediately to the importance of the subject and it was left to Baron De Koppy, to erect the first beet sugar factory in Germany in 1805. This factory had a capacity of 525 tons of beets for the season. Achard also erected a factory in Germany; both turned out small quantities of sugar.

Napoleon's interest in beet sugar—The Napoleonic wars, in progress at the beginning of this century, had so broken up European ocean traffic that cargoes of sugar reached their destination at great hazards and the price of sugar advanced to exhorbitant figures, in some instances 25 cents per pound. This high price greatly stimulated interest in sugar production among Europeans. In his effort to make France self-supporting and independent of other nations, especially England and her dependencies, Napoleon set his learned men to work to discover new sources of sugar. Their first efforts were with the fruit of the grape vine, which, however, does not produce crystalizable sugar. In 1810 Napoleon's attention was attracted to loaves of white sugar, produced by Achard ,from the beet. With characteristic insight and decision, on March 25, 1811, he issued the first decree for the encouragement of the beet sugar industry, setting aside areas of land for the culture of beets and establishing schools for the study of beet sugar chemistry; $200,000 was appropriated for this work. Other decrees carried additional subsidies, and soon factories were turning out sugar in considerable quantity, both in France and Germany. In the wreckage and reorganization of nations which followed Waterloo, not only the sugar factories of France but those of Germany were ruined, the downfall being hastened by the inflow of sugar once more from the tropics as shipping matters settled back to normal conditions. Gradually interest in beet sugar production revived, and, with stimulus from the government, factories came into existence again and beet sugar production became a fixed factor in the manufacturing enterprises of many European countries.

The beet sugar industry in America—The first efforts toward producing sugar from the beet in this country were made at Philadelphia in 1830, without success. In

1863 the Gennert Brothers, from Germany, established a factory at Chatsworth, Illinois, a location illy chosen it is said in soil and climate. After struggling for several years the factory was removed to Freeport, Ill., and later to Black Hawk, Sauk county, this state, where it was started as a co-operative enterprise. As the price of sugar was then very high, this factory should have succeeded; its failure is said to be largely due to the fact that the farmers in the vicinity failed to produce beets in sufficient quantities to keep the factory properly employed. From Black Hawk a portion of the machinery, at least, was removed to California.

About the same time Messrs. Bonesteel & Otto erected a small factory at Fond du Lac, which, after making some sugar, was dismantled and the machinery removed to California. The factory at Alvarado, California, started in 1873, is the first sugar factory which has continued its existence to the present time. Thus we are obliged to record the failure of the first two beet sugar factories erected in Wisconsin. Factories have also been started in Delaware, Maine and Canada, only to end in failure. The causes of failure have generally been the lack of capital to carry on the enterprise and in nearly every instance, unwillingness or inability of the farmers to furnish a full and regular supply of properly grown beets.

Present situation—During the present season sugar beet factories have been in operation at the following points: Norfolk, Neb.; Grand Island, Neb.; Lehi, Utah; Alvarado, Cal.; Watsonville, Cal.; Chino, Cal.

From reliable sources it is learned that the total out-put of these factories will this year exceed 60,000,000 pounds of granulated white sugar. For the first time in their history all or nearly all of these factories have been supplied with all of the beets they could profitably work into sugar.

A large factory was completed and began operations the last of November the present year at Eddy, New Mexico. By the time this bulletin is in print, a factory at Menomonee Falls, near Milwaukee, this state, will have begun operations. This makes eight factories in five states.

THE WORLD'S PRODUCTION AND CONSUMPTION OF SUGAR.

The quantity of sugar consumed by the world and the sources of production is presented in the following table:

TABLE SHOWING THE WORLD'S PRODUCTION AND CONSUMPTION OF CANE AND BEET SUGAR, 1884–1894.—10 YEARS.

Years.	Austro-Hungary.	Germany.	France.	Belgium.	Holland.	Russia.	Other European countries.	Total European sugar production. (Beet.)	Cane sugar production	Total cane and beet sugar production.	World's consumption.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
1884-85	653,000	1,147,000	303,000	116,000	48,000	406,000	18,000	2,691,000	2,177,000	4,868,000	4,640,000
1885-86	370,000	838,000	294,000	63,000	28 000	524,000	22,000	2,139,000	2,238,000	4 377,000	4,640,000
1886-87	550,000	1,024,000	482,000	117,000	40,000	473,000	18,000	2,704,000	2,385,000	5,089,000	5,168,000
1887-88	400,000	959,000	383,000	121,000	42,000	430,000	33,000	2,368,000	2,541,000	4,909.000	5,134,000
1888-89	517,000	990,000	458,000	122,000	38,000	523,000	60,000	2,708,000	2,359,000	5,067,000	5,191,000
1889-90	739,000	1,261,000	778,000	209,000	64,000	446,000	68,000	3,565,000	2,138,000	5,703,000	5,781,000
1890-91	767,000	1,320 000	685,000	181,000	71,000	531,000	105,000	3,660,000	2,597,000	6,257.000	6,038,000
1891-92	774,000	1,097,000	643 000	166,000	43,000	545,000	95,000	3,463,000	2,785,000	6,248,000	6,270,000
1892-93	793,000	1,224,000	580,000	166,000	65,000	450,000	97,000	3,375,000	2,782,000	6,157,000	6,235,000
1893-94	834,000	1,375,000	570,000	220,000	72,000	647,000	119,060	3,837,000	3,197,000	7,034,000	6,932,000
1894-95	1,050,000	1 800,000	814,000	230,000	90,000	600,000	108,000	4,792,000	3,067,000	7,859,000	7,200,000
Increase in 10 years, per cent.	61	57	163	99	88	48	500	78	41	64	55

The above shows that Europe now produces about 4,800,000 tons of sugar from the beet, while the tropical regions of the whole world produce a little over 3,000,000 tons from the ribbon cane. Thus we see that the beet root grown in the temperate regions of Europe has, with the aid of the chemist and the skilled manufacturer, overtaken and surpassed the cane of the tropics in less than a century from its insignificant beginning in the little factory of De Koppy in Silesia, Germany. Germany is the heaviest producer of sugar, the total output of her factories reaching the enormous sum of 1,800,000 tons in 1895.

The Beet Sugar Industry in Germany.—The following table, likewise from *The Sugar Beet*, gives in condensed form information concerning the beet industry of Germany.

TABLE PRESENTING CONDENSED DATA CONCERNING THE BEET SUGAR INDUSTRY OF GERMANY.

	1894-5.	1893-4.	1892-3.
Factories working	405	405	401
Number of steam engines	5,324	5,256	5,122
Total horse-power	94,952	87,424	81,596
Total beets worked (tons)	14,526,030	10,644,352	9,811,940
Total area devoted to beets (acres)	1,098,465	987,723	880,000
Average yield of beets per acre (tons)	12.8	10.9	11.7
Raw Sugar Extracted.	Tons.	Tons.	Tons.
From beets in factories	1,769,331	1,319,006	1,175,137
From molasses (special factories)	61,447	55,165	48,925
From molasses in refineries	4,396	1,427	500
Total raw sugar	1,835,174	1,375,598	1,224,562
Per cent. extraction from beets worked	12.17	12.36	11.98
Per cent. extraction including the work of molasses	12.64	12.92	12.48
Yield of sugar per acre (lbs.)	3,514	3,149	3,276
Weight of beets required to produce 100 lbs. raw sugar (lbs.)	822	809	835
Molasses per 100 lbs. beets worked	2.4	2.63	2.54
Total molasses extracted (tons)	347,125	279,757	246,272
Consumption of sugar per capita (lbs.)	23.5	20.2	21.8

It is but proper to note, before proceeding further, that, as might be expected in a compilation of data of this character from many sources, the figures presented in the various tables do not always entirely agree; in no case are the discrepancies serious.

We find from our table that in the year 1894–5 there were 405 factories in Germany making sugar from the beet. These factories worked up more than 14,000,000 tons of beets grown on more than a million acres of land; 822 pounds of beets produced 100 pounds of raw sugar; one acre of land yielded 3,514 pounds of sugar.

The present status of Germany as the leading sugar producing country of the world has been reached by much the same means as neighboring countries, namely through government aid in the shape of protective duties and export bounties. The

law recently enacted by the German government aids the beet sugar industry, at the same time securing revenue from it. The substance of this law is as follows:

For every pound of sugar exported by German factories the government allows a bounty of 0.3 of a cent a pound.

For all sugar sold by the factories to be consumed in Germany the factory must pay a tax to the government of about 2.1 cents per pound.

In addition each factory pays a license of from $800 to $2,500, according to size of factory.

And finally, all sugar imported into Germany must pay an entrance or import duty of about 4.3 cents per pound, this amount being practically prohibitory.

Bounties.—The bounties paid by some of the countries of Europe to factories producing sugar from the beet, in 1894, were as follows:

Germany	$5 781,250
France	10,000,000
Austria	2,000,000
Belgium	5,000,000
Total	$22,781,250

To which should be added Russia, Sweden and Denmark, making a total of over $25,000,000.

Per Capita Consumption of Sugar.—The quantities of sugar used per individual by the different nations vary greatly, as shown by the following table:

TABLE SHOWING THE SUGAR CONSUMED PER CAPITA IN VARIOUS COUNTRIES.

Countries.	Population 1891.	Per capita consumption, 1890–91.	Countries.	Population 1891.	Per capita consumption, 1890–91.
		Lbs.			Lbs.
Austria	42,750,000	15	Portugal	4,730,000	13½
Belgium	6,150,000	21½	Russia	95,870,000	10
Denmark	2,300,000	41	Spain	17,400,000	9½
England	38,600,000	78½	Sweden and Norway	6,150,000	20
France	39,100,000	29	Switzerland	2,950,000	33
Germany	46,000,000	22½	United States	63,000,000	59½
Holland	4,550,000	27½			

From the above we note that England consumes the largest amount of sugar per capita of any nation. These figures include sugar used in various manufactured articles, a portion of which is, of course, shipped for consumption in other countries. Next to England comes the United States, with a per capita consumption of about 60 pounds. Germany, the greatest sugar producing country of the world, consumes only 22½ pounds per individual. The cause of the low consumption of sugar in the various European countries can be found in the fact that while producing sugar in such quantities, the tax placed by the government on home consumption, guarded by the heavy import duties, makes the cost of sugar so great that the laboring people cannot use it freely as does the same class in England and the United States. On the Continent sugar costs from 7½ to 10 or more cents per pound.

THE UNITED STATES AND THE BEET SUGAR PROBLEM.

Import duties on sugar. From the beginning of our government until the present time, an import duty of some form has always been laid on sugar. Tariff laws regarding sugar are complex, owing to the different grades; stripped of technicalities and condensed as much as possible, the following figures show the import duties laid on sugar of the best grades from time to time brought into the United States:

The duty by the tariff law of 1789 was 1 cent per pound.
1790 was 1¼ cents per pound.
1797 was 2 cents per pound.
1800 was 2½ cents per pound.
1812 was 5 cents per pound.
1816 was 3 cents per pound.
1832 was 2½ cents per pound.
1841 was 2½ cents per pound.
1842 was 2½ cents per pound.
1846 was 30 per cent. ad valorem.
1857 was 24 per cent. ad valorem.
1861, March, 2 cents per pound.
1861, December, 5 cents per pound.
1862 was 4 cents per pound.
1864 was 5 cents per pound.
1870 was 4 cents per pound.
1874 was 5 cents per pound.
1883 was 3½ cents per pound.[1]
1890 (McKinley tariff).[2]
1894 (Wilson tariff), 40 per cent. ad valorem.[3]

Experience of American factories. While it is interesting to know what has been done abroad, it is much more in line with this bulletin to present results actually obtained in our own country under present conditions. The tables given below, prepared by the American Agriculturist, present a great amount of information on the topic in hand. These tables show steady and surprising gains with each added year, and speak volumes for the success of this great industry.

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[1]The average duty collected under this tariff for the 6 years, 1885–1890, amounted to $53,437,000 annually.

[2]Sugar not above No. 16, Dutch Standard, free, with a bounty of 2 cents per pound on home production. The amount of bounty paid for the fiscal year ending June 30, 1893, was $7,342,078; for 1893, $9,375,131; for 1894, $12,100 269.

[3]And 1-10 cent per pound additional on sugar not above No. 16, Dutch Standard, that has received an export bounty, and 9-40 cent additional on such sugar above that standard. Total duty collected for the fiscal year ending June 20, 1896, $28,808,140. C. E. T.

TABLE SHOWING RESULTS OBTAINED BY TWO AMERICAN SUGAR BEET FACTORIES DURING FIVE YEARS.

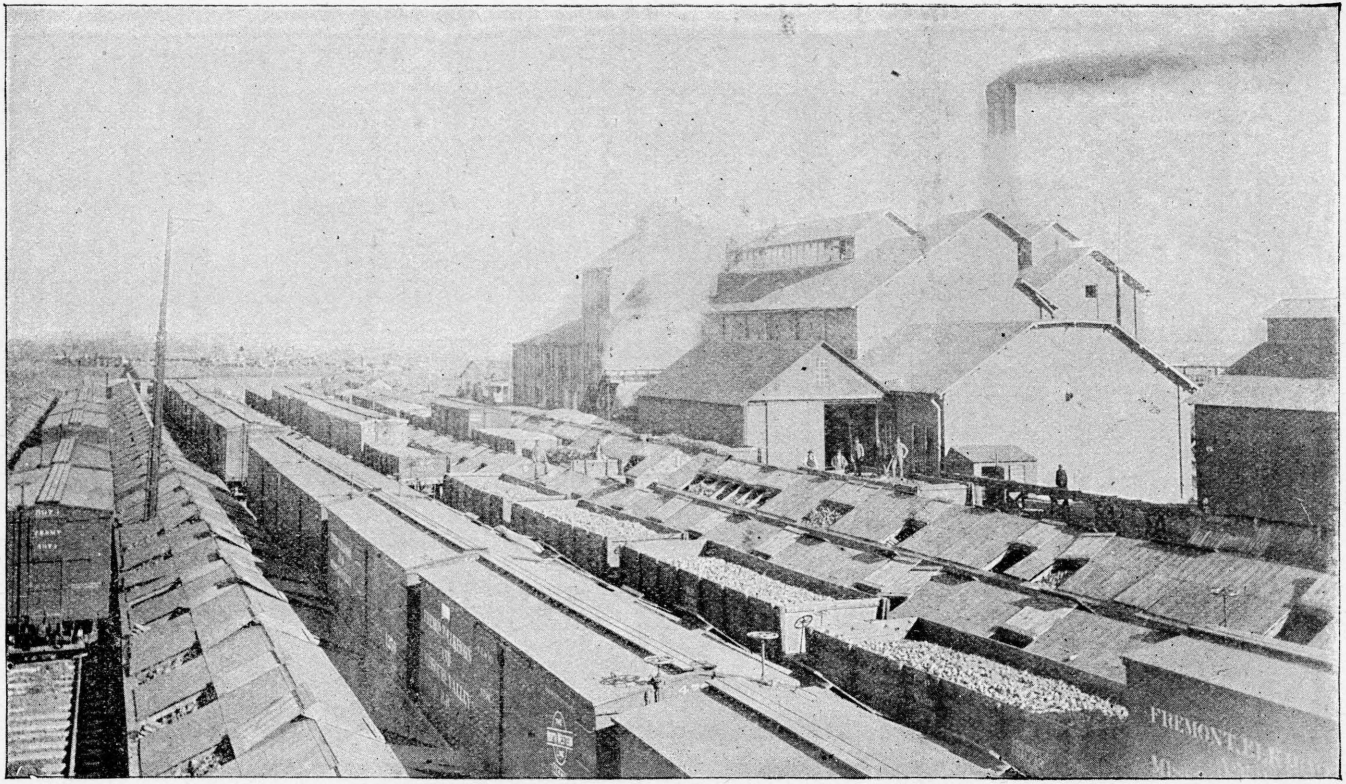
Factory at Lehi, south of Salt Lake City, Utah.

	1891.	1892.	1893.	1894.	1895.
Acres of beets grown	1,500	1,500	2,755	2,850	3,300
Tons of beets produced	9,960	9,816	26,800	32,694	38,108
Average yield of beets per acre, tons	6.6	6.5	9.7	11.47	11.54
Per cent. of sugar in beets	11.0	11.8	11.6	12 7	13.5
Purity of sugar per cent	80.0	80.0	79 5	80.2	81.5
Crude sugar per acre, pounds	1,452	1,534	2,250	2,913	3,116
Pure sugar per acre, pounds	1,162	1,227	1,719	2,336	2,539
Began making sugar	Oct. 12	Sept. 26	Sept. 19	Sept. 25	Sept. 5
Finished making sugar	Dec. 8	Nov. 13	Dec. 21	Jan. 5	Dec. 31
Days in operation	58	49	94	103	118

Chino Valley Beet Sugar Company

	1891.	1892.	1893.	1894.	1895.
Acres of beets grown	1 800	3,488	4,191	4,778	7,529
Tons of beets produced	13,080	26,266	49,353	43,773	83,035
Average yield of beets per acre, tons	7 26	7 50	11.7	9.16	11.03
Per cent. of sugar in beets	13	14	14	15	15
Crude sugar per acre, pounds	1,888	2,100	3,276	2,748	3 309
Sugar per acre, 80 per cent. pure	1,510	1,680	2,621	2,198	2,670
Began making sugar	Aug. 20	July 13	July 31	Aug. 2	July 9
Finished making sugar	Oct. 31	Oct. 11	Nov. 4	Oct. 24	Nov 14
Days in operation	73	91	97	85	129
Average weight of beets worked daily, tons	179	288	509	526	644
Average weight of sugar made daily, pounds	28,108	86.852	15.592	111.431	161,129
Total weight of sugar made, tons	1,026	3.952	7,532	4,736	10,393
Average price paid farmers per ton, beets	$3 90	$4 26	$4 26	$4 66	84 35
Average return per acre	$28 37	$31 95	$49 84	$42 69	$47 98

The first table given is for the sugar beet factory located at Lehi, south of Salt Lake City, Utah; the second table is for the Chino Sugar Beet Co., whose factory is located in Southern California, east of Los Angeles.



Norfolk, Neb., Beet Sugar Factory, with freight trains loaded with beets in the foreground. No view could better illustrate the magnitude of the beet sugar industry than this does.

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Pounds of sugar per ton of beets.—The tonnage of beets worked up at the Norfolk, Neb., sugar factory for the past five years, and the yield of sugar per ton of beets for the same period, are as follows:

Year.	Tons of Beets.	Pounds of sugar	Pounds of sugar per ton.
1891	8,183	1,318,700	161
1892	10,725	1,698,400	157
1893	22,625	4,107,300	181.5
1894	25,633	6,000,000	218
1895	27,204	4,991,300	183.4

Where the money goes.—The Chicago Inter Ocean, investigating the Lehi, Utah, sugar factory operations for the year 1893, reports the expenses of that factory for various items to be as follows:

6,800 tons of beets, which cost	$142,233 96
4,500 tons of coal at $3	13,500 00
200 tons of coke at $17.10	3,420 00
1,600 tons of lime rock at $2.50	4,022 50
40,000 double sugar bags at 14½c	5,800 00
4,150 yards of heavy duck at 15c	622 50
1,050 yards of German duck at 50c	525 00
6,000 sounds sal soda	150 00
4,500 pounds of tallow	270 00
30,000 pounds of sulphur	600 00
10,000 pounds of muriatic acid	350 00
Laboratory and other supplies	5,000 06
Paid for labor	52,923 80
Total cash outlay to produce 4,000,000 pounds of sugar	$230,417 64

The number of people employed in the factory, exclusive of boys and girls, was 200.

The cost of producing the sugar, as stated above, is higher than it should be for several reasons. The Lehi factory is located in the interior of our country, where wages and supplies are both higher than further east; on the other hand, the price of sugar is also high. This year, with a much larger output, the cost of production at this factory will no doubt be materially decreased.

The reader is urged to go over the above list of expenses, and observe how many industries are touched and livened when the people of the country begin to manufacture their own sugar.

Sugar production and consumption in the United States.—In 1884 the sugar consumption and production in the United States was as follows:

	Lbs.	Lbs.
Sugar imported		4,335,193,881
Sugar produced in the United States from ribbon cane at the south	600,000,000	
From sorghum	8,000	
From beets	45,000,000	
From the maple tree	7,000,000	
Total home production		653,400,000
Consumption		4,988,593,881

Wheat and sugar.—The metropolitan press and our agricultural papers never send forth an issue without more or less notice of the wheat markets and the conditions of our export wheat and flour trade. We talk about wheat as though it overshadowed every other industry in this country, actual or possible. To set ourselves right, as to the relative merits of wheat exports and sugar imports, let us review the matter for the last five years. Our exports of wheat and flour and imports of sugar and molasses are presented in the following table:

TABLE SHOWING VALUE OF THE SUGAR AND MOLASSES IMPORTED INTO THE UNITED STATES, AND THE VALUE OF THE WHEAT AND FLOUR EXPORTED FROM THE UNITED STATES TO FOREIGN COUNTRIES, 1891 TO 1895, INCLUSIVE.

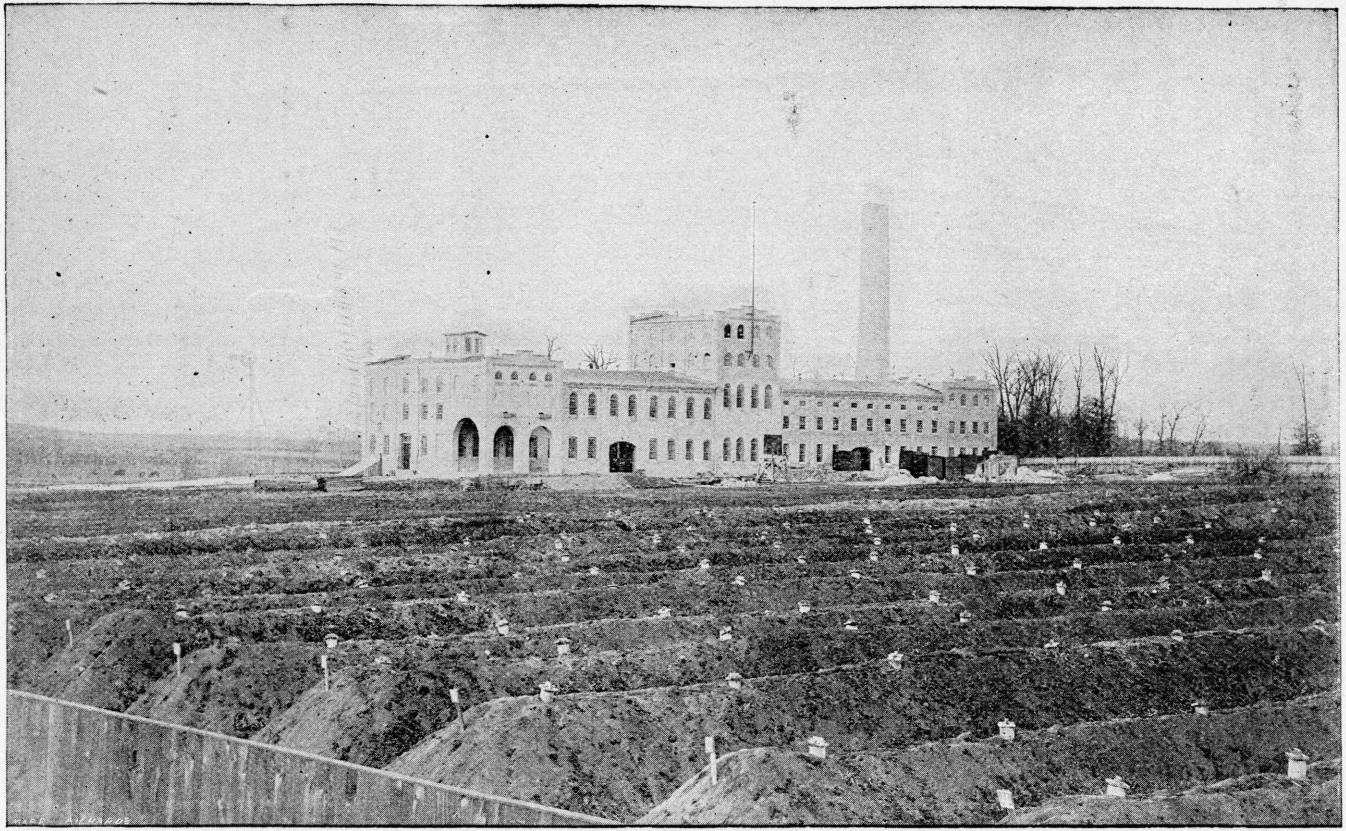
	1891.	1892.	1893.	1894.	1895.	Totals 1895-6.
Imported.						
Sugar	$105,728,216	$104,408,813	$116.255,784	$126,871,889	$76,462,838	$529,727,538
Molasses	2 659,172	2,877.744	1,992 334	1,984,778	1,295,146	10,809,174
Total						$540,536,712
Exported.						
Wheat	$51,420,272	$161,399,132	$93,534,970	$59,407,041	$43,805,663	$409,567,078
Wheat flour	54,705,616	76.362.283	75,494,347	69.271,770	51,651,928	326,485.944
Total						$736,053,022

The table shows that during the five years ending with 1895 we have shipped to other countries $736,000,000 worth of wheat and wheat flour. In the same time we have brought into this country more than $540,000,000 worth of sugar, this sum representing its cost at the ports of entry and not including duties paid. If we add the duties exacted by the government, the total cost of the sugar consumed by our people is nearly or quite as great as the total value of all the wheat and flour exported.

The situation for Wisconsin.—Allowing a consumption of 60 pounds of sugar per individual and a population of 2,000,000 people, the sugar requirements of our state call for 120,000,000 pounds; at 4½ cents per pound we have an aggregate cost of $5,400,000, which may be stated as the sum that Wisconsin must send each year to Europe or the tropics to pay for the sugar she uses. [1]Were we as a people exercising the intelligence and foresight which we will not allow others to charge as lacking, all of this sum could be saved to our commonwealth, even if we sold no sugar to our neighboring states. The sum of $5,000,000 divided into payments to the farmers for beets grown, to the laborers and experts for factory operation, to the railway companies for drawing fuel and other supplies, would prove a marked stimulus to our agriculture because it would bring more consumers into our state for the other products of the farm as well as taking some of our acres, now producing crops in plethora, out of competition and giving them over to a new industry.

The experience of beet sugar countries.—It is a fact noted by all travelers and most keenly recognized by European governments, that the farmers in the beet growing districts are thrifty and getting on in the world beyond those in all other districts, dairy regions, perhaps, only excepted. In this country the farmers in the

[1]It is estimated that three such factories would be required to supply the city of Milwaukee alone with sugar, or four to supply Cleveland. C. E. T.



View showing Menominee Falls Beet Sugar Factory in the distance. In the foreground are the beet pits in which over 7,000 tons of beets await treatment. Dec., 1896.

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vicinity of the beet sugar factories of Nebraska, Utah, and California are awakening to the fact that a beet crop brings them more money than any other system of farming available to them. To produce the sugar consumed in Wisconsin will call for 20 or 25 beet sugar factories. Is their profitable maintenance by a full supply of beets of good quality a possibility, or are we outside the boundaries of this industry? This subject will be considered in the topics which follow.

Director Henry here records the erection of a beet sugar factory at Menomonee Falls, Wis., about 19 miles northwest of Milwaukee, under the general management of Mr. K. B. Korn. As shown in the cut on page 14[5] the building is a substantial brick structure, 58x248 feet in size. The building cost $42,000 and the entire factory is estimated to cost not to exceed $160,000. The capacity of the factory is 275 tons of beets per day of 24 hours. Two shifts of 50 men each will be required to operate it. Mr. Korn claims that, owing to improved machinery and the arrangement of the same, he can operate this factory with about half the force required in European factories. The water for washing the beets comes from the Menomonee river, near by; water for use in the diffusion cells and elsewhere comes from an artesian well on the grounds. The company has a ten-year contract with 350 farmers for growing beets.

THE SUGAR BEET IN WISCONSIN; RESULTS OF INVESTIGATIONS BY THE EXPERIMENT STATION.

For three years, 1890–2, this station not only grew sugar beets in considerable quantities on its own farm, but distributed seed to more than fifteen hundred Wisconsin farmers, requesting, in return, that they send samples of beets grown from this seed to our station for analyses.

Technical points explained.—Before proceeding further let us have a clear understanding on a few points of much importance; these the beet grower should fully understand at the very beginning in order to work intelligently.

In the pages which follow we speak of the per cent. of sugar in the juice and the co-efficient of purity. Let us understand the meaning of these terms. A hundred pounds of sugar beets contain about 95 pounds of juice. This juice not only contains sugar but various other substances, largely mineral matter, which are a great hindrance, causing serious losses of sugar during the manufacture. A hundred pounds of average beet juice will carry about fifteen pounds of solid matter, of which twelve pounds may be sugar, and three pounds matter not sugar. If we divide the number of pounds of sugar (12), by the total pounds of solid matter (15), we get .80, which sum is called the co-efficient of purity; that is, beet juice with 15 parts solid, 12 of which are sugar, is said to have co-efficient of purity of 80. If the sample of juice contains 16 parts solid matter and 12 parts sugar, as before, then the co-efficient of purity is only 75. When reducing the beet juice to make sugar, each pound of foreign matter, not sugar, keeps at least one pound of sugar from crystalizing. This true, we see at once that the manufacturer desires beet roots not only carrying much sugar but also with a high co-efficient of purity. Immature beets, those grown on soils rich in vegetable matter or fertilized with fresh barnyard manure, those grown on land recently cleared from the forest, or on drained swamp lands, are all

[5] Attention is called to the ventilation of the beet pits, as shown in the illustration—a point which the writer has learned from unpleasant experience to be one of prime importance. C. E. T.

liable to carry a great deal of solid matter not sugar in the juice, and consequently are quite unsatisfactory to the sugar mauufacturer. Large beets are likewise always poor in sugar. The leaf stems of the beet, as well as the crown of the beet root itself, also carry much foreign matter. In practice the manufacturer recovers about 7 out of every 10 pounds of sugar contained in the beet root.

Quality of the beet sugar.—Whenever the subject of beet sugar is brought forward the first inquiry usually made is, "is beet sugar white like other sugar and does it not have a peculiar taste?" In its very beginning, when struggling for recognition in Europe, the beet industry was handicapped by the claim that its sugar was not equal in quality with that yielded by the cane plant of the tropics. England did not wish to recognize any competitor with the cane sugar of her dependencies. In brief, to answer the questions asked above, the refined sugar from the beet root equals in all particulars that yielded by the cane plant. Enormous quantities of beet sugar are now being shipped to this country from Europe, mainly from Germany, and the chances are more than even that the persons who question the purity and flavor of the beet sugar are using it daily in their tea and coffee.

What the counties show.—The farmers receiving seed from our station during the three years previously named, forwarded to us 517 packages of beet roots for analysis. The result of all this work is condensed in the following table, where it is presented by counties.

TABLE GIVING RESULTS OF ANALYSIS OF SUGAR BEETS GROWN ON 517 FARMS IN 59 COUNTIES OF WISCONSIN, 1890 to 1892 INCLUSIVE.

County.	No. of samples analyzed.	Average weight of beets.	Sugar in juice.	Purity co-efficient.
		Lbs.	Per ct.	Per ct.
Adams	3	1.46	11.99	76.1
Barron	3	1.24	12.74	77.0
Brown	4	2.30	10.75	74.9
Buffalo	9	1.31	13.48	77.4
Clark	7	1.34	11.76	69.1
Crawford	4	4.26	10.09	72.0
Calumet	8	1.03	15.92	82.8
Chippewa	13	2.41	12.72	77.4
Columbia	19	3.45	12.28	75.2
Dane	12	1.75	13.77	77.5
Dodge	13	2.64	11.77	75.8
Door	3	1.67	14.59	80.0
Dunn	13	2.02	12.48	70.9
Eau Claire	10	1.71	11.70	76.0
Fond du Lac	9	2.05	12.59	75.0
Forest	1	1.85	9.64	72.5
Grant	9	2.34	11.76	79.0
Green	6	1.32	12.83	77.5
Green Lake	1	2.55	11.31	78.1
Iowa	7	2.17	11.32	74.9
Jackson	1	4.12	7.79	65.6
Jefferson	23	1.52	13.84	78.3
Juneau	6	2.31	13.04	76.0
Kenosha	1	2.68	12.71	78.1
Kewaunee	28	2.24	13.92	79.9
La Crosse	9	2.17	12.88	76.3
La Fayette	4	1.86	12.27	77.0
Langlade	1	1.60	12.91	81.4
Lincoln	3	.63	10.53	56.2
Marathon	9	1.25	12.67	76.5
Marinette	2	3.26	8.77	64.5
Manitowoc	16	2.17	13.17	80.3
Milwaukee	6	1.85	15.48	83.4
Monroe	16	2.08	12.31	76.3
Ozaukee	5	1.90	13.14	79 0
Oconto	12	2.15	13.73	80.7
Outagamie	14	2.37	11.48	75.2
Pepin	5	2.37	14.71	77.1
Polk	1	.93	11.09	75.4
Portage	8	1.58	12.02	75.1
Racine	4	2.13	14 27	80.6
Richland	8	2.06	11 95	75.9
Rock	17	1.71	12.96	76.7
St. Croix	8	1.19	12 55	74.7
Sauk	6	2 10	12.05	75.4
Sawyer	1	2.88	10.69	73.8
Shawano	8	1.64	10.97	66.7
Sheboygan	25	1.93	11.98	72.4
Taylor	15	1.49	13 61	78.2
Trempealeau	5	1.73	13.61	79.3
Vernon	11	1.96	12.19	75.6
Walworth	10	2.31	12.99	77.4
Washburn	1	.68	12.00	76.6
Washington	17	1.82	13.79	81.1
Waukesha	19	2.42	12.87	77.2
Waupaca	14	1.82	12.76	77.1
Waushara	3	1.44	12.95	76.3
Winnebago	14	1.69	13.53	76.7
Wood	7	2.12	13.25	79.1
Average by counties			12.44	76.0

THE SUGAR BEET IN OHIO.

For comparison with the foregoing table the following table is given, which shows the results of analysis by Dr. H. W. Wiley, Chief of the Division of Chemistry, United States Department of Agriculture, of samples of sugar beets growing in Ohio, in 1891, as reported in bulletin 33 of the National Agricultural Department. C. E. T.

TABLE GIVING RESULTS OF ANALYSES OF SUGAR BEETS GROWN ON 49 FARMS IN 19 COUNTIES OF OHIO IN 1891.

County.	No. of samples analyzed.	Sugar in juice.	Purity co-efficient.
Ashtabula	2	13.88	82.1
Auglaize	2	10.50	69.2
Coshocton	1	11.83	76.9
Clark	7	10.90	70.8
Erie	18	12.15	76.7
Geauga	1	14.00	78.5
Hancock	4	17.15	76.9
Harrison	3	12.82	81.3
Henry	2	11.88	74.4
Lorain	2	12.43	77.3
Licking	2	12.10	69.4
Marion	1	12.25	76.1
Meigs	1	9.55	77.8
Montgomery	3	13.00	76.7
Morrow	2	17.30	85.7
Ottawa	1	14.40	77.3
Seneca	1	13.23	83 2
Trumbull	10	13.82	80.2
Wyandot	1	12.85	76.3
Average by counties		12.95	77.2

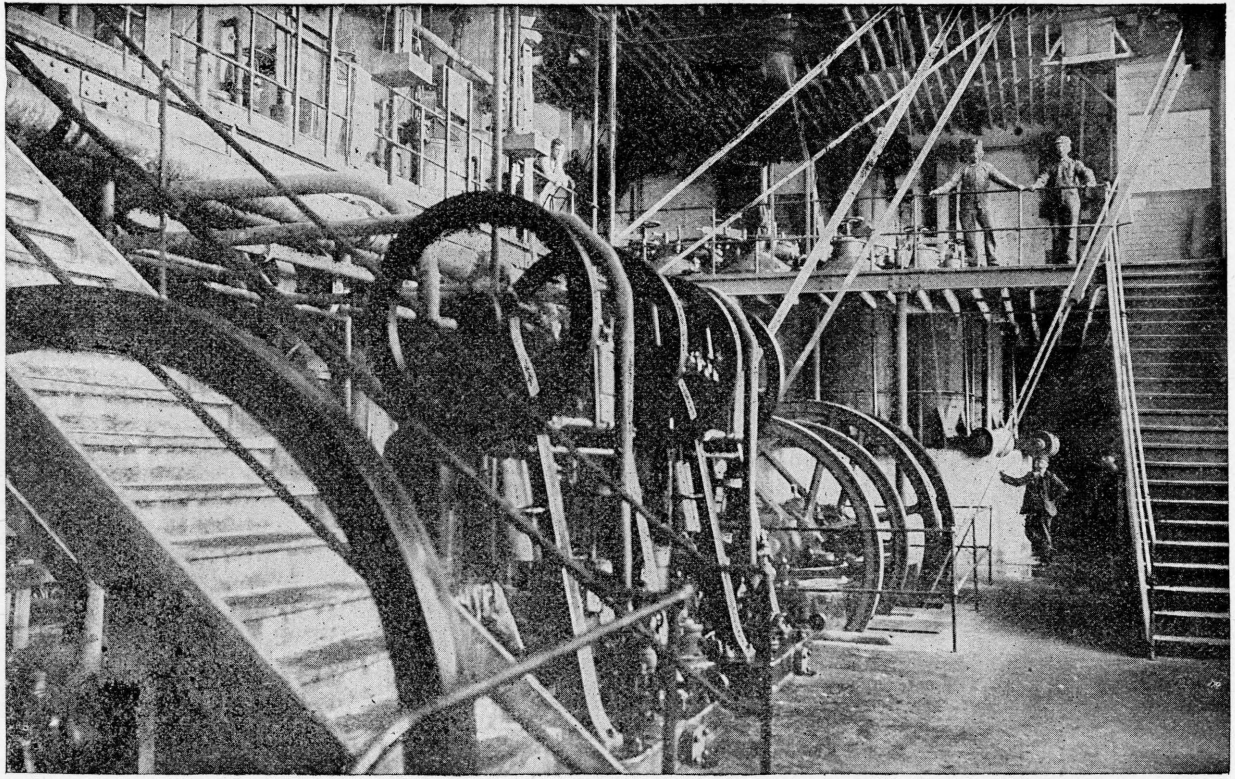
THE COST OF PRODUCING A CROP OF SUGAR BEETS.

Study of the cost of growing beets at the Wisconsin station.—To ascertain the cost of growing beets, one and one-third acres of land were planted to this crop by our station in 1890, and an account kept of the labor expended for the care of the beets after the land had been plowed until the crop was laid by. To show what was done, and when, the following is transcribed from our farm journal:

(Area, 56,260 square feet, or 1.3 acres.)

This plat was in clover the preceding year, and had been fall-plowed.

May	27, man with team and harrow	4	hours
May	28, man planting with hand planter	4	hours
June	9, man and horse cultivating	3	hours
June	9, man uncovering small beet plants after cultivator	9	hours
June	18, man and horse with cultivator	3	hours
June	26, men hand hoeing	24	hours
June	26, man and horse cultivating	5	hours
June	27, men hand hoeing	5	hours
June	27, man and horse cultivating	2½	hours
July	9, man and horse cultivating	4	hours
July	15-17, men hoeing, thinning, and transplanting	119	hours
July	28-29, man and horse cultivating	9	hours
July	29-30, men hand hoeing	41	hours
August	18, man and horse cultivating	4	hours



Interior view of Norfolk, Neb., Beet Sugar Factory, presented to give the reader some idea of the great size and great variety of heavy machinery employed.

After this last date the weather was quite dry, and the beet plants being large with heavy foliage, the weeds did not trouble. The plat was in very fine condition every way. The effect of the clover roots on the soil was most beneficial, keeping it loose during the whole season and making the operations of cultivating and weeding very easy. A good many plants were lacking in some parts of this plat, and the vacancies were carefully filled July 15–17; the transplanted beets lived, but never attained any size and were not pulled. The work of transplanting occupied fully fifty hours of time; it is here counted, though no results came from it. Summing up, we have:

175 hours' time of men, at 10 cents per hour	$17 50
4 hours' time of man and team harrowing, at 25 cents	1 00
30⅓ hours' time of man and horse cultivating, at 15 cents	4 57
Allowance for plowing land	1 25
Total cost of labor in growing beets on 1.3 acres	$24 32

Actual yield of washed beets from this plat, 57,770 pounds.

This makes the cost of cultivating the crop only 84 cents per ton. The expense of plowing the land, cost of seed and the allowance for pulling, topping and drawing the beets to the factory would together about equal this sum, making the whole cost of the crop say, $1.75 per ton. This, it should be remembered, however, is with a yield of over 21 tons of roots per acre.

The following year, 1891, a two acre field of beets was grown with the cost for labor as given below:

Plowing and preparing the land	$ 2 00
Planting and cultivating the crop:	
304 hours' time for 1 man	30 40
22 hours' time for man and horse	3 30
Harvesting and hauling the crop:	
111 hours' time for one 1 man	11 10
28 hours' time for man and team	7 00
	$53 80

This season was one of unusual drouth and the two acres yielded but little over 14 tons of washed beets. This makes the growing and harvesting of a ton of beets cost $3.76, with no allowance for rent of land or cost of seed. It is an excellent example of how the cost of production may be greatly increased through a diminished yield of beets.

The cost of growing a beet crop, providing the work is well done, is almost as much for a small yield as for a large one, the only difference being slightly lessened cost for pulling and drawing fewer roots to the factory when the yield is small.

Perhaps nothing on this subject is better than the experience and figures given by R. M. Allen, manager of the Standard Cattle Company, Ames, Nebraska. Mr. Mr. Allen has grown as high as 560 acres of beets in a single year. Not long since he harvested an average of 15 tons of beets per acre from 500 acres of land. To aid in this work a trained beet grower was brought from Germany and the best of German machinery for beet cultivation was imported. Following the strictest business methods, Mr. Allen keeps an account of each and every operation in the beet field, and this carefulness and accuracy makes his statements unusually valuable and helpful at this time. The cost of growing a crop of beets in 1894 at the Ames plantation is given as follows:

TABLE SHOWING THE COST OF RAISING A BEET CROP BY THE STANDARD CATTLE CO., AMES, NEB., 1894.

	PER ACRE.
Manuring	$2 00
Plowing	2 01
Seed	2 00
Seeding	30
Harrowing	50
Rolling	31
1st hoeing	1 44
Bunching	2 12
Thinning	3 72
2nd hoeing	5 25
3rd hoeing	4 81
4th hoeing	2 91
Cultivating	1 92
Sundry expenses, time keeper, killing bugs, etc	77
Cost of laying-by	$30 16
Harvesting	4 00
Plowing out	2 00
Hauling and loading	2 13
Total cost of crop	$38 29

Allowing ten tons to the acre, the total cost of this crop put on the cars is $3.83 per ton; with 15 tons per acre, the cost would be about $2.50 per ton. Such were the results in 1894. With increased experience in handling the crop Mr. Allen made the following statement in an address before the Nebraska Beet Growers Association a short time since: "The cost ot beets to Nebraska growers, from my personal experiences, in which all figures have been recorded in books of account, indicates that beets can be grown and put on cars, without including any charge for rent, all the way from $1.50 up. The richest land, in a favorable season and under the best tillage with favorable circumstances, appears to make it possible to deliver the beets for $1.50 a ton. This is quite too small a figure to represent the average cost to farmers, and must represent the minimum cost. The average yield must be regarded as in the neighborhood of ten tons an acre, but this is so frequently and largely exceeded in favorable localities that it is quite justifiable in estimating the cost of beets to consider a larger yield than ten tons as probable and to take it into account in figuring the cost."

From all available information the writer believes it reasonable to place the minimum yield of beets for Wisconsin at ten tons per acre; with better culture this may run to 15 or 18 tons, and in rare instances to 30 tons per acre. The larger yields will come in favorable seasons with those who give special attention to the crop, having acquired experience in its production. The lowest price paid in Europe for beets is $3.50 per ton; the common price there as in this country is $4.00 per ton. A yield of ten tons per acre means a gross return of $40 per acre. Thirty dollars should cover the cost of labor in producing the crop and that necessary to its delivery at the factory. This leaves $10 per acre for rent and fertilizers after paying the farmer liberally for all his work. Following a proper rotation, the farmer need pay little or nothing for fertilizers for many years to come, at least. As extras, the farmer will have several tons of beet leaves, and can secure from the factory several tons of beet pulp at a small cost for each acre of beets grown. It will cost more intelligence, though but little more work, to produce larger yields per acre than ten tons; thus possible profits may be materially increased over the figures here given. In Nebraska and California farmers growing beets often clear $20 and even $30 per acre from a beet crop.

As the cost of producing the crop is one of the vital points in the problem before us, I give some additional experience:

Beginning with 1878, field beets, including both mangolds and sugar beets, were regularly cultivated on the farm of the Ohio State University in lots of an acre or more each year, the first four crops being raised under the immediate supervision of the writer. It was soon discovered that the work of hoeing and thinning consumed the major part of the labor required for the production of the crop, and in 1881 an experiment was made for the purpose of learning whether this work might not be considerably reduced. To this end, the beets were planted upon a deeply plowed clover sod, the land being first thoroughly pulverized, then marked with the ordinary sled marker, making a narrow furrow about one inch deep, and in this furrow the beet seed was dropped by hand, one seed in a place, and six to eight inches apart.

The result of this planting was a comparatively thin stand, and it was cultivated with but one hoeing, and with only such thinning as could be done with the hoe. The quantity of seed saved by this method of planting was nearly or quite sufficient, in this case, to pay the extra cost of the planting, but it would be safer to soak the seed first and plant only such as show signs of germination.

In this experiment the total cost of producing and harvesting the crop was reduced to $17 per acre, with wages at $1.25 to $1.50 per day. This is no doubt a lower cost than can be safely accepted as the average, necessary cost, but the experiment showed conclusively that by some such method the cost might be considerably reduced.

In 1885, Dr. Henry A. Weber, the superintendent of the same farm, produced a crop at a cost of about $23 per acre, as reported in the annual report of the University for that year.

In 1890 aud 1891, this station, occupying the same farm, produced two crops at the following cost, as reported in our bulletin for February, 1892:

1890.

Preparation of land	$4 00
Seed	1 20
Cultivation	15 40
Harvesting and storing	10 76
Total	$31 36

1891.

Preparation of land	$7 44
Seed	1 20
Cultivation	17 88
Harvesting and storing	12 32
Total	$38 84

The preparation of the seed bed in 1891 required more work, the plants required more cultivation, and the cost of storing was greater, be-

cause the beets were pitted, instead of being stored in a cellar, as in 1890.

In both these cases the beets were grown on stubble land; the seed was sown thickly with a drill, and as shown, the cost of cultivation, which included much hand work, was excessive.

It will be observed that the cost in these cases corresponds closely with that given by the Standard Cattle Co., in which the hoeing, bunching and thinning consumes two-thirds of the entire cost of cultivation, or more than half the entire cost of production; but in all the Ohio work the cost is estimated on the basis of $1.25 to $1.50 per day for labor of man and $3.00 for that of man and team, hence a deduction of 20 per cent. should be made in comparing with the cost given at the Wisconsin station.

In harvesting, as well as in cultivation, a great saving of labor may be accomplished by cutting off the tops with a sharp hoe and plowing out the roots.

These points are dwelt upon because of the conviction that a material reduction of the hand labor now supposed to be necessary must be accomplished before this crop can become established in Ohio agriculture. In Europe, where wages are very much lower than here, it may be profitable to expend a large amont of hand work upon the crop; but if Ohio farmers cannot produce it without so much of this back-breaking work, they will not produce it at all, unless driven to it by a necessity more dire, or encouraged by a profit greater than is yet apparent. I have faith to believe, however, that our farmers can and will devise means to reduce this labor cost, either in the way suggested or through larger use of machinery in cultivation and harvesting. C. E. T.

Yield of varieties.—In 1890 two plats of beets planted with several varieties were grown with the following results:

TABLE SHOWING RESULTS OBTAINED OF TWO PLATS OF BEETS DURING THE SEASON 1890.

	Area grown.	Yield of beets.	Per cent. sugar in the juice.	Calculated beets per acre.	Calculated sugar per acre.
Plat A.	Sq. ft	Lbs.		Lbs.	Lbs.
Dippe's Vilmorin	2,470	3,040	16.76	40,420	6,419
Bulteau Desprez Richest	8,352	11,804	14.81	51 900	7,304
Simon Le Grande White Improved	26,375	27,866	16.39	39,930	6,218
Dippe's Kleinwanzleben	28,750	25,650	15 74	34,150	5,106
Plat B.					
Dippe's Vilmorin	13 311	11,920	15.74	29,430	4,399
Le Maire's Richest	22,264	21,006	16.32	34,360	5,368
Flor. Desprez Richest	20,685	24,844	14.84	46,710	6,575

Since about seven-tenths of the sugar in the juice of such beets can be actually recovered, we find that a crop of beets equal to the best in the above table will yield about 5,000 pounds of sugar to the acre worth at 4.5 cents per pound, $225. Such a yield is, however, beyond that obtained except in rare cases. Ordinarily the yield of beets per acre is from 12 to 15 tons,[6] and the yield of sugar per acre from 160 to 180 pounds, per ton of beets. It is entirely possible, under the best of conditions, to grow 30 and even 35 tons of beets per acre. No farmer should base his estimates upon such a yield, however.

When the beets are ready for the factory—Having ascertained that Wisconsin's soil and climate enable us to produce large yields of sugar beets and that these beets range from fair to excellent in sugar content and co-efficient of purity, there still remains one most important factor in the problem, viz., the length of the working season for a factory. The number of days a beet factory can run is measured by the date when the beets are first ready for working and the time when winter's cold forces the factory to close down. Most fortunately, Mr. Woll, of this station, has come to our help on this point, in his studies of the maturity of the beet root.

In 1890 large plats of beets were grown containing different varieties with different widths of planting. Beginning early in September, samples from each plat were analyzed, generally at weekly intervals, to ascertain the sugar content and the co-efficient of purity.

The results are summarized in the tables given below.

TABLE SHOWING MATURITY OF BEETS—WISCONSIN STATION, 1890.

Plat A. [Distance between rows 20 in., between beets in the row 8 in.]

Date.	Dippe's Vilmorin.			Bulteau Desprez Richest.			Dippe's Klein-wanzleben.			Simon Le Grande White Improved.			Average per cent. sugar in juice.	Average purity co-efficient.
	Av. weight of beets.	Per cent. sugar in juice.	Purity co-efficient.	Av. weight of beets.	Per cent. sugar in juice.	Purity co efficient.	Av. weight of beets.	Per cent. sugar in juice.	Purity co-efficient.	Av. weight of beets.	Per cent. sugar in juice.	Purity co-efficient.		
	Lbs.		Lbs.				Lbs.			Lbs.				
Sept. 5.....	.99	11.87	78.2	.53	10.79	73.4	.78	11.77	77.5	1.05	11.81	82.9	11.56	78.0
Sept. 15.....	1.22	12.91	86.6	1.27	12 72	80.2	1 06	13.02	83.4	1.30	12.51	77.7	12.79	82.0
Sept. 22.....	1.00	15.29	85.3	1.39	13.87	83.1	1.04	14.74	83.3	1.41	13.38	82.6	14.27	83.0
Sept. 30.....	0.88	15.78	86.9	1.33	15.27	84.1	.90	14.06	82.7	1.09	15.38	84.7	15.12	84.6
Oct. 7.....	1.18	17.64	85.6	1.27	14.85	83.9	1.30	16.14	83.7	.86	16.68	87.1	16.33	85.1
Oct. 16.....	1.48	15.43*	84.5	1.24	15.52	86,1	1.07	14.33	84.8	1.98	14.60	84.2	14.97	84.9
Oct. 23.....	.92	16.01	85.0	.71	16.03	87.2	1.20	15.92	87.7	1.12	16.15	83.8	16.03	85.9
Oct. 30.....	1.25	16.76	86 3	1.25	14.81	83.9	.90	16.39	82.2	1.51	15.74	83.2	15 93	83 9

[6] These yields have been repeatedly obtained in our work —C. E. T.

* A sample taken Oct. 17 gave 16.37 per cent. of sugar, coefficient 84.9 average weight 1.17 pounds.

Plat B—[Distances between rows 30 inches, between beets in the row 10 inches.]

Date.	Dippe's Vilmorin.			Le Maire's Richest.			Florimond Desprez.			Average per cent. sugar.	Average purity co-efficient.
	Av. weight of beets.	Per cent. sugar in juice.	Purity co efficient.	Av. weight of beets.	Per cent. sugar in juice.	Purity co-efficient.	Av. weight of beets	Per cent. sugar in juice.	Purity co-efficient		
	Lbs.			Lbs.			Lbs.				
Sept. 9	1.16	13.08	76.9	2.12	10.76	79.5	1.45	10.05	71.7	11.30	76.0
Sept. 15	1.08	12.17	80.1	1.40	9.88	74.3	1.75	10.14	72.5	10.73	75.6
Sept. 22	.85	16.05	87.3	1.57	14.09	85 8	1.48	11.45	79.5	13.86	84.2
Sept. 30	.89	17.32	84.9	1.27	14.37	83.8	2.44	13.44	82 9	15.04	83.9
Oct. 7	1.13	16.10	84.9	1.57	14.56	83.5	1.35	12.59	79.5	14.42	83.0
Oct. 16	1 42	17.30	84.8	2.31	14.52	80.0	1.96	13.80	81.6	15.21	82.1
Oct. 24	1.19	15.57	84.7	1.61	14.98	83.2	1.95	12.83	78.7	14.45	82.2
Nov. 1	1.30	15.74	86.0	2.27	16.32	82.8	1.99	14.84	82.4	15.63	83.7

It will be borne in mind in discussing this subject that the minimum quality desired by the beet sugar factory is a sugar content of 12 per cent. with 80 as the coefficient of purity. The higher these figures can be placed the better the results secured by the factory.

We observe that in Plat A the variety "Simon Le Grande," had, on September 5th, a sugar content of 11.81 with a co-efficient of purity of 82.90. Thus we found one variety of beets nearly rich enough and quite pure enough to warrant starting the factory on September 5th. By September 15th, the average of four varieties in Plat A gave a sugar content of 12.79 per cent. with 82 as the coefficient of purity, Only one variety in Plat B had reached the desired standard on the same date. On September 22d, both plats averaged much higher than the minimum standard. Mr. Woll considers that by October 1st the beets were fully ripe, no general progress towards a higher sugar content or a greater co-efficient of purity being observed after this date.

The season in which these trials were undertaken was, on the whole, quite favorable, and probably our results give an earlier date for attaining the minimum standard than can usually be reached. It seems probable, that a factory located any where on or south of a line from Madison to Hudson, Wis., will be able to begin operations by the 20th of September in years of normal climatic condition.

Allowing that a Wisconsin factory can start operations September 20th, we have the remainder of that month, all of October and half of November, or 55 days, when there is certainly nothing objectionable so far as cold is concerned. For the last half of November some considerable protection might be necessary for the roots, yet it is believed that ways will be found by which the beets can be carried in proper condition for work to December 15th or even later. It seems to the writer that a factory can count on 70 days for a working campaign in Wisconsin with much assurance of no serious trouble for that period.

THE SITUATION IN WISCONSIN [7]—RECOMMENDATIONS.

Our studies to this point have shown how science brought to the notice of man the possibilities of producing sugar from the humble beet root, how it has improved this root, and how at the present time the temperate region of Europe with its relatively high-priced labor has surpassed the tropics with their cheap labor in producing the world's sugar. We have seen how the industry has grown to its present enormous proportions in Germany, France and other European countries from a most insignificent beginning, dating only eighty years back, and how, after a long series of failures and discouragements, it has at length gained a foothold on American soil. We have learned from the studies of this Station that Wisconsin's soil and climate form a favorable combination for the successful growth of sugar beets. Whether Wisconsin shall now advance to the position now offered her by nature and become a beet producing district, with factories turning out thousands of tons of sugar annually from beets grown on our farms, is a question for our people to answer, for the solution of the problem rests wholly with ourselves. Let us study, still further, matters relating to this great topic.

Wisconsin in the beet belt—Many persons suppose that the beet plant will produce better yields of sugar in the tropics than with us, but such is not the case. This root is at its best where the summer temperature averages 70 degrees Fahrenheit. A line marking this average temperature runs from Kenosha northwesterly across our state to Hudson, and as the summer heat is practically the same for a hundred miles or more on either side this line, the whole of Wisconsin may be regarded as in the sugar belt.[8]

Beet culture not exhaustive to the soil—Chemically considered sugar is produced by the union of the elements of carbonic acid gas and water; both these constituents are given to the farmer by nature without charge. Of course there is nitrogenous and mineral matter in the plant substance also, but we should not forget that all the beet leaves remain upon the farm and the pulp can be returned to it from the factory for feeding stock. By feeding leaves and pulp to cattle the farmer is able to return to his field in barn yard manure about all of the valuable elements taken from it in this crop.

If we need more conclusive evidence on this subject we have but to turn the experience of European farmers, who have come to regard the beet root with the highest favor as a cropping plant. More than this, experience goes to show that there is no better crop in a rotation than the beet root, which seems to leave the the soil in a most excellent condition for the following crop. A study of European beet districts shows that these carry just about as many cattle and give just about as large total yields of other crops as if no beets were grown.

Beet culture adapted to small farms.—The cost of growing a beet crop amounts to from $25 to $30 per acre, about all of which sum is expended in labor. The farmer, by utilizing the energies of himself and his family, can save all of this sum, which will make a handsome income in itself, from a comparatively small area of land. The weeding, hoeing and thinning of beets are all operations which do not call for a degree of exertion or skill beyond that which can be exercised by almost every member of the family. The farms in Wisconsin are generally small, our people are frugal and industrious and will raise no objections to working in the beet fields if fair returns for labor may be secured. From our villages and cities large numbers of persons can be secured in the summer time to aid when extra labor is called for; all of these facts are of the highest importance, in guaranteeing a large tonnage of beets in the vicinity of factories to be erected.

Factory location—A beet sugar factory consumes many car loads of coal each day it is in operation and large quanties of supplies are required. Beets are often, shipped to the factory from distant points in train loads daily. A beet factory should therefore be located on a line of railway and if possible where the railroads from different districts converge. In addition to good railroad facilities a large supply of water is very important. A beet sugar factory requires not less than two million gallons of water daily, enough to supply quite a city. The beets float into the factory in a stream of running water, and large quantities of water are required for washing them and for other factory purposes.

A beet field calls for a large amount of hand work expended in weeding, hoeing and thinning the crop, and hundreds of extra employees are required in beet districts a few weeks each summer. Again, large numbers of persons find employment each fall in gathering the roots, topping them, loading into wagons, cars, etc. If possible, then, the beet district should be not far from cities or towns where a floating population can be secured without heavy cost for this particular work.

Length of the working season.—This matter has already been partially considered in reporting investigations of this Station. Remembering that a sugar factory costs hundreds of thousands of dollars, the importance of the length of the working season is evident. Having removed all doubts as to the suitability of our soil and climate for beet production, and certain of the ability and willingness of our farmers to grow this crop provided a fair profit is assured them, and assured also that fuel can be secured at a very reasonable cost, there remains but one single factor of doubt in the problem, viz., the length of the working season. The beet season is determmined by the days which intervene between the ripening of the first beets and the shutting down of operations because of winter's cold. We have estimated the minimum working period at 55 days, and believe it can be extended 30 or 40 more by storing roots, as is now practiced in the sugar districts of Russia and by the factory at Lehi, Utah. Much encouragement is given by the experience of our farmers growing potatoes in Central Wisconsin; no matter how cold the weather is in winter, our potato producers may be found drawing their crops long distances over the snow to the potato warehouses and to the freight cars by which they are carried to the centers of consumption. If we can handle a potato crop in cold weather we should be able to supply beet roots to the factory satisfactorily up to Christmas time at least.

The sugar beet a thoroughbred.—When, nearly a century ago, a loaf of beet sugar produced by Achard was shown to Napoleon Buonaparte, that monarch was told, in reply to an inquiry, that the juice of the beet root carried 6 per cent. of sugar, a marvelous amount, as was then thought. Now, whole fields of beets are grown which carry 14 per cent. of sugar in the juice, while single specimens have yielded 20 and 25 per cent. sugar. As it was the chemist who first brought the possibilities of this plant to the attention of the commercial and manufacturing world, so chemistry has been put to the highest service in constantly increasing the sugar content of the beet root. The present high sugar yield of the beet is the result of the most rigid selection of the roots by experts. To be satisfactory, the beet must be smooth on its surface and without prongs and branches, so as to have no places where dirt may be concealed at the time of washing the roots. Large beet roots carry little sugar, the ideal root weighing from one to three pounds. Those of the most desirable form are smooth and spindle-shaped, and such are selected for growing seed. Plugs are taken from roots having the desired form and size in such a way as not to seriously injure them, and the juice of these plugs is analyzed to determine the sugar. Those which are satisfactory are planted the following spring to produce seed. The seed thus secured is planted, and the beets resulting are again analyzed, as before, and only the best chosen. This process is repeated for several

years, when, finally, all of the seed grown is turned over to the farmers for producing beets to be consumed by the factory. The beet roots so carefully selected for seed are called "mother beets." Millions of dollars, literally, have been expended in scientific studies of the beet root, with the wonderful results above noted. All of this care and selection results in making the beet root one of the most artificial of plants, and it responds immediately to abuse by yielding less sugar, or, under good culture, by holding its sugar content up to the high standard set for it.

Cost of factories—On this subject the counsel of Dr. Wiley, chief of the Division of Chemistry, Department of Agriculture, Washington, should be carefully considered. In Bulletin 27, entitled, "Culture of the Sugar Beet," he writes:

"The cost of a beet sugar factory depends on so many conditions that it will be impracticable to give anything more than a rough estimate of it. Much depends upon the character of the building itself, and this, for various reasons, should be made fire-proof, thus entailing the construction of a building of considerable cost. In regard to both the building and machinery, the total cost will depend largely upon the capacity of the house, the cost, however, does not increase in the same ratio as the capacity. In other words, it may be stated that the cost of a beet sugar factory capable of working 400 tons of beets per day would not be double cost of one working 200 tons. A beet sugar house based on an estimated capacity of 300 tons per day would probably be more in keeping with the character of the houses which are to be built in this country for some time to come than any other. With a proper fire-proof building, and the best and latest machinery, such a factory would cost, ready for work, from $150,000 to $200,000. Factories, of course, can be built at much less cost than this, but doubtless at the sacrifice of efficiency in some of their parts, so that true economy would advocate the construction of a high priced factory of the best workmanship and of the most approved modern style."

Wishing to secure further estimates of the cost of a factory at this time, a letter was addressed to Walburn-Swenson Company, Chicago, Ill., manufacturers of sugar machinery. Mr. Swenson, of this company, is a graduate of our own State University, and has been foremost in inventions and manufacture of machinery for sugar production, his machinery finding sale on plantations in Louisiana, Cuba and the Sandwich Islands. The reply is as follows:

CHICAGO, ILL., Nov. 19, 1896.

DEAR SIR:—We have your favor of Nov. 17th, and I take pleasure in answering your inquiry.

First: The cost of the machinery complete in every particular for a beet sugar factory having a capacity of from 300 to 350 tons of beets per day, including all pumps for water supply, boilers, engines, &c., the whole to be of the very best design and workmanship and capable of making white sugar direct from the beets, without any refining, would be in the neighborhood of $170,000 on cars in Chicago.

The machinery for a factory having double this capacity would cost about $260,000.

These prices, you will of course understand, are somewhat approximate as prices of material vary very much. Copper tubes, which enter largely into the construction of such a plant, cost one-third more than a year ago.

I think it would be advisable, in case a larger factory is contemplated, to first build one having a capacity of about 300 tons, making or arranging the building to have room to increase the capacity later on, which can be done with very little extra cost over building it in that way at first, and by building it properly, it can be so arranged that nothing will be necessarily sacrificed, either in the arrangement or size of the machinery.

The cost of a first-class brick building, including boiler house for the smaller size factory, would be from forty to fifty thousand dollars. This would also include foundations, lime kilns, &c. Just what the cost of the sheds for holding the beets would be I cannot say, but I am of the opinion that four or five thousand dollars would be sufficient to cover this item. All the castings, &c., for the lime kiln are included in the price of machinery, and the brick work would be easily within the above cost of buildings.

A building for the larger plant would probably cost $75,000 if put up in every way first-class.

I shall be pleased to give you any further information you may require for your bulletin. There is no doubt but what there is a great misconception as to the cost of a factory of this kind, and many people write us thinking that with an old building and second-hand boiler and engine that has been used for some other purpose, they have a good nucleus for a beet sugar factory, and for twenty or thirty thousand dollars it can be all fitted up. Any attempt of this kind is simply throwing money away, and it would be a great misfortune to the beet sugar business to have it gone into without sufficient capital to erect a factory of proper size, as well as of the most modern construction.

The machinery, of course, comes very high, but it must be built in such a way that there will be no mistake about its working, as breakdowns and delays are fatal to the industry during the short season they have to work.

Yours very truly,

WALBURN-SWENSON CO.
[Signed], M. SWENSON, Manager.

From every reliable source there comes evidence that a first-class beet sugar factory is an expensive enterprise.

Beet factories must be large because the season for working up the beet roots is comparatively short and an enormous amount of material must be handled in two or three months' time. Further, there must be employed chemists to analyze the beets from the field of each patron, as well as to test the juice at each and every stage during conversion to sugar. Then there are the experts, such as sugar boilers, machinists, engineers, &c. The cost of wages for all of these employees is no more when operating large machinery and supervising large operations than when employed in small ones. It is most unfortunate, in some respects, that we cannot build small factories in Wisconsin, but the experience of all beet regions shows plainly that this is an utter impossibility. Small factories are lost in the fierce struggle for supremacy going on in this industry as in all others.

The farmer's part in securing a sugar beet factory.—The farmer's position in this question is primary and a most important one; his first thought should not be in the direction of securing a factory, but rather in preparing himself to carry out properly his own part in the transaction, viz., growing beets of high sugar quality in ample quantity to keep a factory in operation to its utmost capacity during the whole campaign. Those interested should therefore address themselves at once to such subjects as the proper kind of beet seed, the machinery necessary for planting and cultivation, suitable soil, preparation of soil, planting, cultivation, harvesting, etc. When a community representing hundreds of farmers have gained some experience in this direction they will be ready to guarantee the delivery of the beet crop from thousands of acres to a factory. When this stage has been reached by any Wisconsin community, the writer believes it will not be at all difficult for it to secure a modern factory to work up the beets it stands ready to furnish.

Hints for a sugar beet association.—A community interested in this subject should form a sugar beet growers' association. Each member should agree to grow from one to three acres of beets, keeping a record of the amount of seed required, date of planting, hours of team and hand labor required in planting, cultivating, harvesting and drawing roots to pit or cellar. As true sugar beet seed is expensive, each member need plant but a limited area with such seed, devoting the rest of the ground to the mangel or to low grade sugar beets raised from cheap seed. The farmer need have no fear that he will lose any money on such a venture, for if no factory results, the beets grown will more than pay all expenses incurred. The crop can be profitably fed to live stock and a few years' experience will show it to be one of the most valuable produced on the farm for that very purpose. With the ripening of the beets in the fall each member of the organization should bring samples of true sugar beets taken according to directions, to a central point where they should be packed and shipped to our Experiment Station. This Station stands ready to analyze and report, without charge, the results of all determinations as to the sugar qualities of beets sent to it.[9] Such an effort will teach the farmers to grow the best kinds of beets and to know what it costs to grow them. It will place any community which may follow such an intelligent plan in the lead in securing a factory.

Where communities will not come together for joint effort, let individuals interest themselves in the subject and do all they can to advance a knowledge of modern sugar beet culture. We cannot be too earnest on the subject of previous preparation in beet growing. To illustrate how easy failures may come about in matters like this, we have only to point to the creamery factory craze which afflicted many of our northern states only a few years since. In hundreds of instances small cities, towns and even farming communities, were induced to advance from five to ten thousand dollars for the purpose of building a creamery; to-day scores of these

[9] The Ohio Station has held the same offer open for years, and continues to do so C. E. T.

buildings stand idle, monuments of the folly of people whose enthusiasm and willingness to spend money to advance the interest of the community, as they thought, far exceeded their judgment and knowledge of conditions essential to success. These creameries generally failed because there were not cows enough in the vicinity to supply them with milk; a fact which should have been thoroughly investigated before a dollar was spent in factory construction. A beet factory without a large supply of good beets must prove a failure, no matter how perfectly it may be built and how well it is manned with skilled operators. Several beet factory enterprises failed in this country years ago, because the farmers would not or could not supply the beets required. The two factories in Nebraska were in existence several years before the farmers supplied sufficient beets to make a profitable season's run. Let us in Wisconsin take heed of failures elsewhere, noting their causes and carefully avoiding them.

Points in beet culture.[10]—A whole bulletin would be required to properly discuss this one topic; only a few suggestions can be here given. Land which will grow a good crop of corn or potatoes will be fouud satisfactory for a beet crop. Our lands in Wisconsin are yet so generally fertile that our farmers in experimenting with beets should use manures very sparingly at first or not at all, as manures generally tend to reduce the purity of the juice. Beets should not be planted on marsh lands or those containing too much vegetable matter, as such soils, though growing large beets, give roots with low sugar yields and with a low coefficient of purity in the juice. The land for beets should be well plowed and the surface made as fine as possible by repeated cultivating, using a planker, fine tooth harrow, etc. The soil should be quite free from weed seeds, as weeds are the most serious obstacle in growing this crop. As soon as the ground is warm enough for corn, beet seed may be planted. The seed is sown by drills which plant from one to several rows at a time. Trial plots may be planted by hand. The largest yields of beets are obtained with rows only eighteen or twenty inches apart; since our farmers are familiar with the use of cultivators for growing potatoes they had, perhaps, at first, better have the rows thirty inches apart and cultivate the beets as they would a potato crop. With experience, closer methods of rowing may be followed. It requires from twelve to fifteen pounds sugar beet seed to plant an acre, seeds being dropped every one or two inches. Cultivation may begin two or three days after the seed is planted, if the surface of the field is free from corn stalks and other trash. A light harrow with slanting teeth may then be drawn over the land, such harrowing destroying myriads of sprouting weed seeds without disturbing the beet seeds. As soon as the rows of beets can be seen, regular cultivation follows, and when the plants are three or four inches high they are carefully thinned, leaving one plant every seven to eight inches. After the first thorough weeding and thinning future cultivation is simple and inexpensive.

In conclusion.—The data gathered by our station show that the soil and climate of Wisconsin form a combination which insures large yields of good sugar beets. Our people living on small farms are thrifty, industrious, and willing to inform themselves how to grow beet crops and to expend the necessary labor thereon. We have before us the experience of several beet factories now in successful operation in this country. Authentic reports bring us this information that there are no more thrifty and prosperous communities anywhere than those engaged in beet root growing. The only possible factor in the way of success is the shortness of the working season, and here we have no greater handicap than some other beet regions where the industry is successfully prosecuted.

In view of all these facts, the people of Wisconsin are urged to give to the beet sugar industry that consideration which it is justly entitled to by its magnitude and importance.

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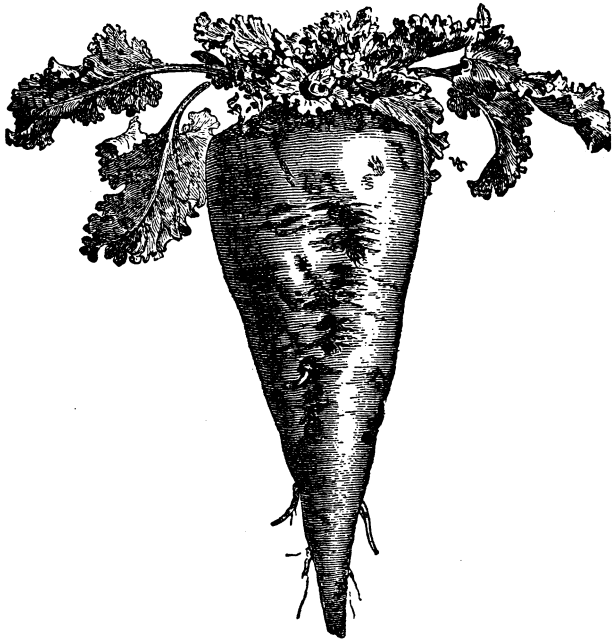
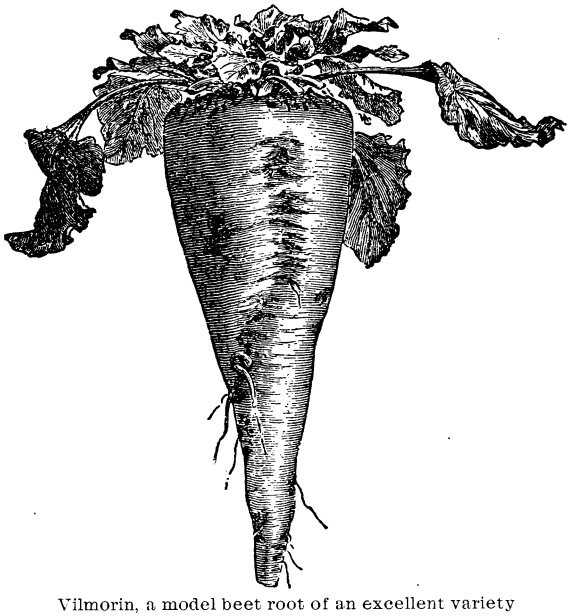
[10] See page 23.



Kleinwanzleben, a model sugar beet root.



Vilmorin, a model beet root of an excellent variety